#99-05 (Sep-Oct 99)

EUROGRAM

***E**UROPEAN **O**FFICE OF **A**EROSPACE **R**ESEARCH AND **D**EVELOPMENT*

CC HIGHLIGHTS

The Russia Initiative is one of AFOSR's best international efforts. Two major 5 year programs, one in directed energy and one in hypersonics, have been funded by AFOSR. Each received approximately $400K a year from AFOSR but FY00 is the last year in the original plan. Ideally, these programs represent a team effort with the team consisting of a directorate technical expert, an AFOSR expert, and an EOARD program manager. The directorate expert, with the help of the AFOSR and EOARD personnel, decides which programs to fund and EOARD does the contracting. We'd like to compliment Mr Lee Bain, AFRL/PR, and Dr Harro Ackermann, AFRL/DE, for their leadership in their programs. Dr Charbel Raffoul and Dr Martin Stickly, EOARD program managers, have also done an exceptional job in managing the work. In FY01, we will most likely continue these efforts in a new Russian (or Former Soviet Union) effort, as well as expand into a few new technical areas. Please contact us with your suggestions as to what technical area we should tackle next.

The technical areas of directed energy and hypersonics converged in July in Poland. Dr Stickley, our lasers and optics expert, reports on the XXIV International Conference on Phenomena in Ionized Gases, which was supported by both Drs Raffoul and Stickley (page _). While the conference may not have revealed any drastically new findings, the attendance shows the international interest in this area. Scientists from 38 countries attended with the highest attendance from Japan followed by Russia, Poland (host country), France and Germany.

EOARD has just said goodbye to Col (select) John Santiago and his wife, Emily. John's contributions to AFRL's international efforts are numerous but his vision for automating the workplace makes him a valuable Air Force resource. Best wishes, John, for creating a new home for your vision in Space Command.

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LIAISON OFFICER REPORTS

Col. Gerald O'Connor
Commander

Conference: ADDA Conference, University of Strathclyde, Glasgow, United Kingdom, 26-28 July 1999. This was the third ADDA conference with previous conferences held in 1991 and 1994. In 1991 they decided the pace of technology suggested meeting every three years. The 5 year delay since the last conference was not mentioned but the next conference is under discussion. The opening speaker, Steve Harris from Crystal Semiconductors (possibly owned by Cirrus Logic), noted that 24 of the 44 papers presented were "chip" papers and 17 of those were CMOS. He re-iterated Moore's Law, "memory density increases 4x every 3 years" and challenged the audience on how to take advantage of the free digital transistors. His analysis to achieve >110 dB would require 1) increase the oversampling rate (consumes too much power), 2) increase the order of the modulator (instability and too much HF noise) and 3) use multi-bit ADC's. He predicted integration would be the key for closed, well-defined items (ie cell phones). For very high performance items, he predicted separated units, i.e. ADC that took a long time to get exactly right even in 2-micron 15-volt architecture would be kept separate and re-used, with the rest of the electronics integrated on the side.

Zach Lemnios, from MIT Lincoln Lab and previously DARPA, led the Future Trends and Limits of ADC's discussion. He suggested the high points of the conference were the papers on optical/photonic ADC's. Allan Belcher stated that, despite the 6-7 year trend per improvement in bit/order of magnitude of frequency, the state of the art is closer to 2-3 years when the commercial sector had the need and makes funding available. Papers broke down into two classes 1) those funded by DARPA, DERA(UK), and DSTO (Australia) and 2) those focusing on commercial needs. Of special note were the sizable contingents from University of Manchester Institute of Science and Technology (UMIST) [not U of Manchester] and the National Microelectronics Research Centre, Ireland (http://nmrc.ucc.ie/) with neighboring Motorola. These sites may be of future interest.

Conference: Doing Business in Russia, Moscow, Russia; 17-20 August, 1999 The primary host and POC was Olga Gamayunova. Intellectual property rights were a major issue, but there were also briefings by organizations conducting activities in Russia. The UK's DERA spends approximately 2M pounds a year in Russia. Through De Montfort University, England and Bauman Moscow State Institute (not on the sanctioned list, we think)these funds support Ph.D. topics of interest. The student does most of their research in Russia with a Russian and a UK supervisor on topics are approved by DERA. DERA gets the research and Russia trains a future scientist with contacts in the UK. The Russians reported that Germany spends more money than the British. Hence, there are opportunities under our existing bilateral and multilateral agreements to discuss each other's research investments and see if synergy exists through cooperation.

Dr. Charbel Raffoul
Aeronautical Sciences

Site Visit: Department of Mechanical Engineering, University of Bath, Bath, UK, Feb. 1999, POC: Prof. Ismet Gursul. The University of Bath has firmly established itself as one of the best universities in the UK. In the most recent Research Assessment Exercise, it was ranked sixth (out of 191) in the National rankings.

The research portfolio of the University now amounts to 34M pounds with funding coming from the Research Councils, the European Union, charities, business and industry worldwide.

The Mechanical Engineering (ME) Department is one of only five Mechanical Engineering Departments in the country given a 5-star rating (the highest possible grade) in the recent Funding Councils' Research Assessment Exercise. The Department has also been awarded an excellent rating in the latest HEFCE assessment of quality in teaching and learning. The Department is divided into six groups: Manufacturing & Materials; Aerospace Engineering; Thermofluids; Design; Structures & Biomechanics; and Systems, Control and Applied Mechanics and the Center for Power Transmission & Motion Control. Research activities cover fundamental investigations through applied research. Many activities are carried out in conjunction with industry and can involve collaborative programs with other universities both in the UK and overseas. Within the Aerospace Engineering Group unsteady aerodynamic of vortex flows over fighter aircraft, buffeting of wings and fins, aerodynamic flow control, application of pressure sensitive paints in aerodynamic, Micro Air Vehicles, flow-induced vibrations of structures, aeroacoustics, and gas turbine cooling systems are being researched. Buffeting and vortex-dominated flows are strengths of the Group with interaction of leading-edge vortices with flexible fins and active and passive control of fin buffeting among the research projects.

The major facilities in the Aerodynamic Laboratory include: six wind tunnels (including a 2.12m x 1.51m low-speed tunnel and a 223mm x 209mm transonic tunnel capable of generating working-section Mach numbers ranging from 0.55 to 1.25), a 38cm x 51cm water tunnel, a 1.22m x 1.83m towing tank, and a rotating-disc rig. These facilities have comprehensive suites of instrumentation with six-component balances, scanivalve units, a two-component LDA system, hot-wire anemometry, high power Argon laser for flow visualization, infra-red thermal-imaging equipment, gas analyzers, and data acquisition systems. The Department also has fifty Silicon Graphics and Sun workstations and numerous PCs.

The ME Dept. has a current contract with EOARD. The work is entitled: "Interaction of Vortex Breakdown with a Flexible Fin and its control, Phase-1". The contractor, Prof. Gursul will investigate the fin buffeting caused by vortex breakdown and its control. In the first phase, the effect of fin deflections on vortex breakdown will be investigated by flow visualization and flow velocity measurements. Aeroelastic deflections of the fin will be simulated in the first bending mode by forced oscillations of a rigid fin Program, FLTP, starting in 1999.

Conference: Parallel CFD Workshop; Experiences in Implementation, Istanbul Technical University, Istanbul, Turkey, 16-18 June 1999. More than forty researchers from seven countries gathered at the Istanbul Technical University Macka Campus to present their most recent research in "Parallel Computational Fluid Dynamics" within the framework of an Academic Agreement signed between Istanbul Technical University (ITU) and The Indiana University Purdue University Indianapolis (IUPUI). The Workshop is organized by Profs. U.Gulcat of ITU and A.Ecer of IUPUI. The workshop focussed on a review of experiences in providing parallel algorithms for everyday use. There were several keynote lectures and one special lecture. The special lecture "Usage of the New OpenMP Standard on Parallelization" delivered by I. Zacharov of SGI was about the industry standard for parallel processing on Shared Memory Machines. Performance Comparisons ("Efficient Paralellization of an Unstructured Grid Solver: A Memory Centric Approach" D.Kaushik and D.E.Keyes), Tools and Environments ("Explicit Multi-Grid Acceleration Methods for the Solution of N-S Equations" M.Meinke and E.Krause,

"Issues for Large Scale Simulations in the Process Industries" (D.R.Emerson and R.J.Blake),,, Parallel Algorithms ("Efficiency Studies of a Parallel Substructuring Algorithm on Different Platforms" H.U.Akay and S.Kocak), Applications and Domain Decomposition aspects of Parallel CFD ("Some Domain Decomposition and Parallel Algorithm Issues for the Numerical Simulation of a Catalytic Reactor TAP2" M.Garbey) were covered in the invited lectures.

The workshop presented information on a wide range of CFD problems solved with high performance computing means ranging from Cache Based Machines to PC Clusters. Of particular interest was "Parallelization of a 3-D Flow Solver with Special Respect to the Parallel Equation Solver" made by T.Boenisch (HPCC, Stuttgart). Mr.Boenisch discussed the parallelization of the Jacobi line relaxation solver in conjunction with the usage of the additional spliting method in reducing the coupling between the matrix parts located on different processors. With this, the speed-up and scale-up performances on the massively parallel computers become very high for the solution of 3-D Euler and N-S Equations to study suporsonic flows past re-entering space vehicles in a wide altitude-velocity range. Also of interest was "Reducing Parallelization Overheads for Incompressible Flows Using Pseudo-Second-Order Velocity Interpolations" from ITU. This work dealt with increasing the computational efficiency of an incompressible flow solver to the super linear levels with reducing the computational complexity of implicit pressure solver. The N-S solver of this study was developed and tested using PVM on workstation clusters running on Linux. A presentation by A.Ecer (IUPUI), on "Software, Hardware and Algorithm Considerations in Reducing Communication Cost for Parallel Computing" emphasized how to reduce communication costs for solving the 3-D heat equation and the Navier-Stokes Equations on Workstation Clusters running on Unix or NT.

The Book of Abstracts was given to participants at the start of the workshop. Full papers will be published before year's end. The Rector of ITU made a call to host larger scale meetings on Parallel CFD in next millenium.

Conference: Russian Federal Nuclear Center (VNIIEF), St. Petersburg, Russia, 4-9 July 1999. The primary host and POC was Dr. Evgeniy Meshkov.

Site Visit, Institute of High Temperature Materials, Moscow, Russia, 11-16 July 1999 The primary host was Dr. Valentin Bityurin.

Site Visit: DLR. Goettingen, Goettingen, Germany, 12-13 August 1999. The primary host and POC was Dr. Vassilios Theofilis.

Maj Jerry Sellers
Aerospace Structures and Materials

Meeting: University of Surrey, Guildford, United Kingdom, 3 August 1999 The primary host and POC was Dr. Jeff Ward. We discussed a proposal by the Surrey Space Centre for investigating a modular nanosatellite architecture for repeatable mission opportunities. The USAF Academy is very interested in this concept as it offers an opportunity to leverage low-cost technology for repeatable space flight opportunities while creating a ideal academic platform for teaching spacecraft engineering.

Meeting: Astrophysics and Space Research Group, University of Birmingham, School of Physics and Space Research, Birmingham, United Kingdom, 15-17 August 1999. Dr. George Simnett hosted this meeting. The purpose of the visit was to serve as an independent panel member for the critical design review (CDR) of the Solar Mass Ejection Imager (SMEI). SMEI is a being built by the Univ. of Birmingham under contract to AFRL/VS under a cost-sharing program. The purpose of SMEI is to develop

forecasting models for geomagnetic disturbances caused by solar mass ejections. These disturbances can disrupt or destroy expensive on orbit assets. SMEI has been manifested along with the NRL WindSAT payload on the Coriolis mission scheduled for launch in December 2001. The Coriolis program is managed by Air Force Space Test Program office (SMC/TE). During the CDR, the Univ. Birmingham with their co-developers at the University of California at San Diego (UCSD), presented a comprehensive review of all payload design parameters including structural and electronic components and instrument performance issues. The CDR also include representatives from AFRL/VS, SMC/TE, Aerospace Corp., NRL and the prime contractor for the spacecraft SpectrumAstro. Visitors were given a complete tour of Univ. Birmingham's extensive clean room, mechanical and electronic fabrication and testing facilities. Overall results from the CDR were very favorable and the team is on track for the December 2001 launch on a Titan II into sun-synchronous orbit. Additional information on SMEI can be found at http://www.vsbs.plh.af.mil/projects/smei/smei.html

Conference: 13th Annual AIAA/USU Conference on Small Satellites, Logan UT, USA, 22-27 August 1999. The primary host and POC was Dr. Frank Redd.

Dr. Barry McKinney
Information Technology and C4I

Site Visit: Distributed Systems Research Group, Department of Computer Science at Trinity College Dulin, . POC, Prof. Paddy Nixon http://www.dsg.cs.tcd.ie/index_net.html Paddy.Nixon@cs.tcd.ie. The Distributed Systems Group (DSG) is a research group of academic staff members, post-doctoral and sponsored research students whose research covers all aspects of distributed computing from parallel processing in workstation clusters through support for distributed virtual enterprises to mobile computing. Main research areas include system and language support for distributed programming, the use of object-oriented techniques (such as frameworks, design patterns, and reflection) to build customizable system software, and all aspects of distributed object computing. Past achievements include the Amadeus distributed object system and a new model of Distributed Shared Memory (DSM) known as application-consistent DSM.

Current work is addressing system support for distributed virtual enterprises, the use of object-oriented reflection to build customizable distributed object systems and techniques for building timely and reliable communication in the Anois project. Prof. Nixon has recently been awarded an EOARD research contract to study the dynamic reconfiguration of FPGA nodes in a distributed computing system. The effort will focus on a specialized portion of a heterogeneous information system, specifically, Field Programmable Gate Array (FPGA)-based nodes. New computing architectures will be investigated that can specify and dedicate FPGA processing elements (FPE) that take advantage of application/algorithm dependent dataflow. The AFRL point of contact for this project is Kevin Kwiat IFG, 315 330 1692.

Site Visit: Department of Electronic and Computer Engineering, the University of Limerick. POC, Dr Khalil Arshak, khalil.arshak@ul.ie. The Electronic and Computer Engineering Department (ECE) at the University of Limerick is one of three Departments in the College of Informatics and Electronics. The department is active in various international initiatives such as ACTS, RACE and ESPRIT. The Telecommunications Research Center is undertaking research projects in Radio and Mobile Communications, Satellite Communications, Communication Networks and Protocols, Network Management, Telecommunications System Simulation, Disk drive systems, and Modulation/Coding theory. There are ongoing projects in UMTS, TINA, DECT, GSM, N-ISDN,

B-ISDN, IN, UPT, TMN. These projects range from investigations of network architectures and protocols to modulation techniques, adaptive equalizers and actual VLSI designs. Standard simulators and CAD tools such as SDT, OPNET, COMDISCO, BONES, CADENCE etc. are used for modeling along with customized software written in C/C++, SDL and Java. The department has recently submitted a research proposal titled, "Development of a robust smart antenna array signal processing algorithm based on antenna array auto-calibration using GPS signals." The AFRL point of contact for this project is Kevin Kwiat IFG, 315-330-1692.

Site Visit: The National Microelectronics Research Center (NMRC), University College, Cork Ireland (http://nmrc.ucc.ie/index.html**).** POC Dr. Jim Greer. Established in 1982 to provide the infrastructure necessary to assist the development of microelectronic and microsystems manufacturing in Ireland, NMRC currently employs 220 researchers and staff and is a research center affiliated with the University College Cork. In addition to their internal development program, the center also carries out contract research and development work in collaboration with industry and third level institutions. The NMRC has collaborated successfully under the auspices of various European Union research programs including ESPRIT (http://www2.cordis.lu/esprit/home.html) and BRITE/EURAM. In 1990, an agreement with the European Space Agency (ESA) established an ESA Microelectronics Technology Support Laboratory (MTSL) in the NMRC. State-of-the-art fabrication cleanrooms are available in the silicon fabrication area, including a class 10 photolithography area and III-V growth and fabrication facilities

AFRL/IF has been pursuing collaborative research opportunities in the area of nanosciences including nanotubular probes, chemical self-assembly techniques, single electron devices and spin-tunneling RAM. Senior researchers from the NMRC have recently participated in EOARD's Window On Science program to personally discuss possible research projects with AFRL scientists in the U.S. Dr. Greer is preparing reprints of the group's recent publications. Please contact Dr. McKinney for detailed information on specific technologies.

Lt. Col. Robert Fredell
International Programs

Conference: International Conference on Composite Materials, Paris, France 5-9 Jul 99. The five-day conference was organized by Dr. Thierry Massard and a large international committee. It attracted more than 1000 participants with multiple participants from the U.S. (several from AFRL were invited speakers). However, the conference was marked by a high percentage of no-shows, both from Western and Former Soviet Union countries.

This biennial international forum is to solve the problems of composite materials and their application to aerospace and other fields. This Symposium addressed Fibers, Metal, Ceramic, and Resin Matrices, Processing, Modeling, Repair, Aerospace Applications and Civil Applications. For further information/copies of proceedings, contact Lt Col Fredell.

Conference: International Committee on Aeronautical Fatigue conference, Seattle WA, United States, 11-16 july, 1999 The primary host and POC was Mrs. Jill Jennewine.

Conference: Language Training at DLI for ESEP, Monterey CA, United States, 15- 19 July, 1999 The primary host and POC was Dr. Jerome Franck.

Site Visit: Royal Military College of Science (Cranfield University), Dept. of Aerospace, Power & Sensors, Shrivenham, Swindon, UK, 3 August 1999. Recommended by LtCol Crisler,

USAFA, the primary host and POC was Dr Rafal Zbikowski. The Shrivenham campus of Cranfield University, home of the Royal Military College of Science (RMCS), is a center of excellence in defense science, technology and management. The Aerospace, Power & Sensors Department is organized into five groups:
- Guidance & Control - control system design for fixed and rotary wing aircraft and missiles, missile guidance, nonlinear and robust control,
- Sensor Systems Group - radar, electronic warfare, microstrip antennas, and electro-optic sensors,
- Communications & Wireless Networks Group - spread-spectrum systems for mobile and fixed wireless applications and adaptive modulation,
- Aeromechanical Systems Group - aerodynamics and aircraft design, and
- Power & Drive Systems Group - thermal and electric power sources and systems

A highly integrated, interdisciplinary approach is used. The main purpose of the visit was to introduce EOARD to the newest Cranfield campus, and to briefly review the revolutionary work being done in "flapping micro-air vehicles." The flapping micro-air vehicles project, under the leadership of Dr. Rafal Zbikowski and in response to a DARPA initiative, is an innovative approach to the aerial reconnaissance of small interior spaces for urban warfare situations. The effort is based in mimicking of the flight characteristics of small insects and the hummingbird. These bio-mimetic devices will be able to hover, fly straight upwards, backwards, etc., all while transmitting data to nearby forces interested in clearing unknown buildings of potential threats. Major challenges exist in control, structures, materials, propulsion, and sensors. The activities of the Cranfield group will be further detailed in an upcoming conference, "Unmanned Air Vehicle Systems," scheduled for 10-12 April 2000 in Bristol, UK.

Dr. Martin Stickley
Geophysics

Conference: Laser Physics '99, Budapest, Hungary, 2-6 July 1999. The primary host and POC was Dr. Jozsef Janszky. The quality of papers at Laser Physics '99 held in the charming, old-world city of Budapest was anything but 'old world'. The 1999 meeting was a huge improvement over the 1997 meeting in Prague. The action in European laser physics was indicated by the source of papers: Russia, 70; USA, 34; Germany, 31; Hungary, 16; France, 10; Poland, 6; Austria, 5. A grand total of 27 countries were represented including China and Brazil. The meeting was partially supported by EOARD.

Since it is impossible for me to comment on all the fine papers presented, I shall feature "Multi-color, mode-locked Ti:sapphire laser with zero pulse jitter" by R. Szipocs et al. of the Research Institute for Solid State Physics and Optics in Budapest. Dispersion must be carefully dealt with to obtain the shortest possible pulses. The laser reported by Szipocs used the combination of a fused silica prism pair and "chirped mirrors". This design produced a laser with two outputs with a 17nm separation between them, a 52nm spectral width of each, and 25 fs pulse widths with zero time jitter between the two outputs. Zero time jitter is enormously important in the application of such ultrashort pulse lasers (for example, to chemistry). Szipocs and his group are the world leaders in the R&D of the mirrors that make this possible: "chirped dispersive dielectric mirrors" or "chirped mirrors". (See 'Theory and design of chirped dielectric laser mirrors' in Applied Physics B 65, 115-135 (1997).) While a surprise to many, at the meeting it was common knowledge that Szipocs' firm, R&D Ultrafast Lasers in Budapest, is the source for the best chirped mirrors in the world. He has demonstrated that such mirrors enable the production of extremely short pulses (see "All solid-state cavity-dumped sub-5-fs laser', Applied Physics B 65, 175-188 (1997).)

Other interesting papers include:
- "Highly stable femtosecond Ti:sapphire and its use in the metrology" by Bagayev, Institute of Laser Physics in Novgorod, Russia. He reports that beats between different modes of the laser are stable to 1.27x10-12 in 50 seconds and suggests ways of measuring frequency intervals up to 10 THz and developing a new type of optical clock with this technology. [clock@laser.nsc.ru]
- "Triggered gamma emission as a precursor to a gamma-ray laser" by Carroll, Youngstown State University, Ohio. He points out that the ability to trigger the emission of gamma radiation in a controllable manner could have very important consequences even if it falls short of being a gamma ray laser. [jjcarroll@cc.ysu.edu]
- "Cold atoms as a source of monochromatic and coherent nuclear gamma-radiation" by Rivlin, MIREA Technical University, Moscow, Russia. He reports that cooling of isomers to a few milli-Kelvin is entirely possible in order to decrease the Doppler width and increase the gain of the gamma ray laser medium. [rla@superlum.msk.ru]
- `Slow light and cold atoms' by Welch et al., Texas A&M, Texas. He reports techniques for slowing the velocity of light to c/100,000 in hot rubidium vapor through the use of electromagnetically-induced transparency (EIT).
- "Optical twister for molecules" by Ivanov, Steacie Institute of Molecular Sciences, NRC of Canada, Ottawa. Strong IR fields can be used to create an "optical twister" – a field that would exert a very large and controlled optical torque on anisotropic molecules. This technique can distinguish molecules with different moments of inertia and thus acts as an optical centrifuge. [misha.ivanov@nrc.ca]
- "Subfemtosecond pulse generation by molecular modulation" by Sokolov, Stanford University, CA. He proposed and analyzed a technique using molecular hydrogen for generating a train of pulses with a spectral bandwidth of 70,000 cm-1 and a pulse length of 0.22 fs. (Sokol is a Hungarian graduate student at Stanford.) [sokol@leland.stanford.edu]
- "Type I noncritically phase-matched second harmonic generation in Gd1-xYxCa4O(BO3)3" by Burmester, Universitat Hamburg, Germany. This is one of a new class of nonlinear optical materials that have high nonlinear coefficients, are transparent in the UV, are nonhygroscopic, have congruent melting and can be grown in large sizes by the Czochralski technique. Noncritical phase matching allows large angular beamwidths and lack of beam walk off. [burmester@physnet.uni-hamburg.de]
- "Laser performance of diffusion-doped Cr2+:ZnSe" by Kuleshov, Belarus State Polytechnical Academy, Minsk, Belarus. This laser is important because it can be tuned in the spectral range of 2.1-2.7 microns. Kuleshov reports a threshold of four microjoules, and a maximum slope efficiency of 53% using a 1.598 micron pump. [kuleshov@ilc.unibel.by]

The program can be found at the conference web site: http://bird.szfki.kfki.hu/lphys99. Please contact Dr. Stickly for abstracts.

Conference: Int'l Conference on Phenomena in Ionized Gases (ICPIG), Warsaw, Poland, 11-16 July, 1999. The primary host and POC was Prof. Jerzy Wolowski. At the 24th conference on this topic scientists were present from a total of 38 countries. Japan had the largest attendance (67) followed by Russia (53), Poland (52), France (38), Germany (36), Czech Republic (24), UK (23), and USA (19). EOARD received substantial visibility for being one of the sponsors.

Of greatest interest to AFRL is airfoil drag reduction. A paper, "Study of plasma generation in supersonic airflow and its effect on drag," reviewing Russian work on this topic was presented by A. A. Rukhadze of Moscow State University. Modification of the air flow near the air vehicle's surface may be achieved by heating the ambient air, by injection of a light gas or by some other method. It was not clear whether the effect seen is due to the plasma or heating of the

gas. The conclusion states "Recent experimental and theoretical studies of interaction of gas discharges with supersonic airflow at plasma aerodynamic experiment have shown good prospects of development and application of plasma technologies in aerodynamics for a considerable improvement of aerodynamic characteristics of vehicles. Plasma formation near the vehicle's surface or near it can be useful for solution of the following actual problems of aerodynamics: drag reduction, altitude control, shock and sound boom attenuation or removal." Hallway conversations indicated that the use of lasers to create the plasma is not the best way to do the job due to complexity and cost. A copy of Rukhadze's paper (in English) is available from Dr. Stickley.

In the plenary session, O. Joubert of CNET/DTM/TFM, Meylan, France reviewed "Trends in plasma processing for ultralarge scale integration technology." He pointed out that 40% of the technological steps in IC manufacture use plasma processes. He reviewed many of the future problems facing scientists, e.g. dielectric etching, undesired growth of layers caused by implantation below them, developing techniques for utilizing low dielectric constant materials, and polymer etching in high density plasmas. He thinks 13 nm (EUV) is definitely the wavelength of the future for photolithography. The x-ray approach has been abandoned because lenses are not available to photo-reduce the mask size causing the mask to be the same size as the final circuit. He feels the industry has solutions for the technology issues in IC production only through 2005. He predicted 10 years from now, the only silicon in an IC will be the substrate – every other material will be new!

"Atomic and molecular processes in astrophysical plasmas" by A. Dalgarno of the Harvard-Smithsonian Center for Astrophysics, Cambridge, MA was a beautiful talk about the sources of ionization in the Universe and the physical atomic and molecular processes that determine the characteristics of the resulting plasmas. His paper states (*I added parenthetical comments*) "The Universe began with the 'big bang' (*no one knows what was going on before this time!*) that was so hot that nothing existed except quarks. The Universe cooled rapidly to a temperature at which the quarks could combine and remain combined in the form of protons. The protons captured electrons to form neutrons and after about 200 seconds, a brief period of nucleosynthesis ensued in which 4He nuclei were created together with trace amounts of 3He, 2H, and 7Li nuclei. (*At this point in time and at no other time, deuterium was created. As it exists in about one part in 10,000 in water, the deuterium you drink everyday is 15 billion years old!*) The temperature at this time was about 109 K and the Universe was a fully-ionized electron plasma, irradiated by photons. Radiation and matter were closely coupled by Thompson scattering of photons and electrons and they shared a common temperature."

"The Universe coasted for about 100,000 years, gradually getting colder and less dense. Any recombination of electrons and charged nuclei that occurred was immediately reversed by photoionization and by electron impact ionization. Eventually though the temperature fell to about 4000 K, the supply of photons and electrons energetic enough to cause ionization diminished, and recombination took effect. In this recombination era, the Universe was transformed from a fully-ionized plasma to an almost neutral gas. Thermal contact between electrons and photons was lost, and radiation and matter subsequently evolved independently. The loss of contact permitted the formation of clumps in the matter which were later enlarged by gravitational accumulation to create the first distinct cosmological objects."

Remarkably, the big-bang-based theory outlined by Dalgano accounts for the amount of deuterium and helium in the Universe. Other support for the big bang theory, in addition to the amount of He and D

in the Universe, are the agreement between the predicted and observed background black body temperature (which he says is a perfect black body), and the fact that the Universe is expanding with increasing velocity as seen from the red shift of light from the most distant stars. The one major feature that does not fit is that 90% of the mass of the Universe appears to be missing, and he feels that a new concept must be developed to explain that.

This ICPIG conference seems especially noteworthy since it brings together such a wide range of fascinating and important topics.

Site Visit: Institute of Electronic Materials Technology, Dept. of Oxide Single Crystals Technology, Warsaw, Poland 15 July 1999 POCs: D. Sc. (Eng.) T. Lukasiewicz, Head of Department and Dr. Andrzej Majchrowski, Institute of Applied Physics WAT, Laboratory of Crystal Growth; (zielj@wat.waw.pl). Lukasiewicz's group receives about 30% of their funds as base support and the rest must be derived from selling crystals. His group concentrates on YAG doped with rare earths (they have achieved the highest Nd concentrations of up to 1.7%); substrates for high temperature superconductors; piezoelectric materials such as lithium niobate for SAW devices and lithium borate for acoustic delay lines; and nonlinear optical materials such as BBB and BBO for second harmonic generation. They grow cesium lithium borate since it is cheaper to grow than BBO and can generate up to the 5th harmonic of 1.06 microns. Their next material will be the oxy-borates.

Majchrowski grows tungstates for Raman shifters, borates as nonlinear optical materials, and sillenites (BGO and related materials) as photorefractive materials. He plans to expand into growing crystals for organic LEDs however, they are unstable – radiation can break the polymer chains.

A third group headed by Dr. L. Kociszewski is developing IR glass (chalcogenide) fibers for image transmission and is seeking support for this work. [itme@frodo.nask.org.pl]

Conference: Wavefront Sensing and Its Applications, University of Kent, Canterbury, UK, 19-22 July, 1999. The primary host and POC was Prof. Christopher Solomon. Sixty participants from 12 countries contributed to this EOARD sponsored meeting. The variety of the papers and their cross-disciplinary nature encompassed aspects such as wavefront sensor design, control design and implementation, novel algorithms /estimation techniques, low-cost adaptive optics imaging systems and astronomical and surveillance imaging.

Adaptive optics systems for surveillance, power beaming and astronomical applications have generally been expensive (from a few to tens of $M). Increased activity and progress on low cost components and systems was demonstrated by papers on liquid crystal technology and its use in wavefront correction systems (Laude, Thomson-CSF, FR, and Love, University of Durham, UK) and Jeff Baker's progress report (Boeing North American, USA) on the low-cost University of Puerto Rico adaptive optics system. The rapid progress and modest cost of the Max-Planck Institute for Astronomy's laser-guide star AO system ALFA was also impressive. A number of authors reported on different aspects of the system.

Interesting developments in theoretical aspects of wavefront sensing and control were also presented. Several contributors (Acosta from University of Santiago, Spain; Rousset and Robert from ONERA. FR; and Solomon from University of Kent, UK) addressed the key issues of optimal estimation and correction of wavefronts using a modal representation. The need to match sensing and control procedures to the prevailing spatio-temporal aberrations and limited flux typical of many imaging/surveillance and interferometry applications was stressed.

This meeting was a lively event with plenty of time devoted to discussion and exchange of information and ideas. Some details of the event, including electronic proceedings, can be found on the Web at http://speke.ukc.ac.uk/physical-sciences/main/School/activiti.htm

Conference: Organic materials for Sensor Protection and Nonlinear Optics, Menton, France, 27 August – 1 September, 1999. The primary host and POC was Dr. Francois Kajzar.

Mr. Jay A. Howland
Physics and Ballistic Missile Defense

Feature Article: Space Debris Observation

When a space debris observation experiment was suggested about two years ago, Dr. George Karabadzhak of Association of Aerospace Engineers, Moscow, Russia proposed the development of an algorithm and software for automatic processing of images obtained from the double channel imaging sensor to observe and measure space debris. A Dual Channel Imaging Sensor (DCIS) has been developed and manufactured. The sensor is now being tested and qualified for a space flight in Lebedev's Physical Institute of Russian Academy of Sciences. When ready, the DCIS will be installed on board the CORONAS satellite and the debris observation experiment will start with the year 2000 CORONAS mission.

The experiment's main goal is to evaluate the space debris population on Low Earth Orbits (LEO) and advance space debris evaluation models. Accuracy of the evaluation depends on the number of particles registered by the DCIS during the one year mission. The DCIS acquires data in the form of images of space limited by its field of view (FOV). These data frames are called image scenes. The data acquisition time must be comparable with the time needed for a debris particle to cross the DCIS FOV to increase the signal to noise ratio. Preliminary analysis of the DCIS parameters showed that for particles from 1-10 cm (the most interesting debris) this time is on the order of one second. Therefore, the DCIS was designed to work in the low frame rate mode with an essential feature being the space debris particle leaves in the image scene a track laying over the starry sky background. For small particles, the track intensity may be very weak so efforts to develop optimal observation plan for better observation statistics have been made to ensure a high sensitivity of the DCIS.

During space monitoring, debris particle detection is a random process. Better statistical characteristics are obtained if more time is used for the measurements. At one image scene per second, the DCIS is relatively fast. However, not all images can be transmitted to the ground since CORONAS has multiple missions and the space debris observation experiment the satellite telemetry system (TMS) with other experiments. Dependant on the capacity of its buffer memory and number of daily telemetry sessions, the number of non-compressed DCIS images the TMS can transmit is estimated to be two orders of magnitude less than the total number of images the DCIS can acquire. Moderate image compressing could increase the number of images transmitted by a factor of 5-10 with no significant loss of information. This still leaves one or two orders of magnitude to make up. An image selection mechanism to select and store for transmission only those frames with a higher probability of containing a particle track should be applied onboard.

A simple algorithm for image analysis considered earlier analyzed the pair of images obtained in both channels of the DCIS at the same time. Pixels with intensities higher than predetermined threshold values were located and their positions were compared. in each images. The pixels that contained a signal from a debris particle had the same coordinates in both images while randomly distributed noise provided different pixel positions. This idea was used for image selection and the

algorithm test showed relatively good results in processing compiled images with idealized noise distribution.

The next step in advancing the algorithm takes the track-like nature of the signal into account. Summing up the pixel intensities along the track may improve the noise statistics by an order of magnitude. However, checking the track availability of all locations and directions in the real image scene takes an unacceptably long time. Therefore, Fourier transformation of the correlation function is used to reduce image processing time. The price for this reduction is a loss of the algorithm sensitivity. The trade-off was carefully analyzed and a compromise was found that ensures excellent performance of the algorithm.

The data processing algorithm has been developed and tested. The running time is comparable to the DCIS data acquisition time. It will be further optimized with development of the onboard processing system hardware. The algorithm tests found that use of this new algorithm onboard the CORONAS satellite will increase the number of useful images transmitted by a factor of 50 or more.

Dr. Roy Phillips
Policy and Strategy

Site Visit: AFOSR, Ballston VA, United States, 24-28 July, 1999 Meetings at AFOSR with J.Janni, V.Cox, J.Tishkoff, S.Walker, and others regarding Russian Initiative and site visits to Russia. Meetings with Leta O'Connor, SAF/GC and Maj Jeff Christoff, SAF/IAQ, regarding ISTC.

Dr. Peter Ouzts
NASA Liaison

Conference: 5th International Symposium on New Aviation Technologies, Moscow, Russia 17-22 August, 1999 The primary host and POC was Mrs. Victoria Koulkova. EOARD was the major sponsor of this Symposium organized by the Central Aerohydrodynamic Institute (TsAGI) and held bi-annually. Conference sessions covered aircraft aerodynamics, flight dynamics, control systems, stability and control of aircraft, aircraft strength, engine manufacturing, flight testing technology, and avionics. Flight safety for the new millennium was the theme of the conference. A plenary session included presentations on Russian Civil Aviation of the XXI Century (TsAGI), Global Aviation Safety (Boeing), Next Generation Gas Turbine Engines (CIAM), Aviation Materials for the XXI Century (VIAM), and Flight Test Technologies and Testing of Aviation Engineering Prototypes (LII).

While conference attendees represented all Western nations, the majority of papers were by Russian authors from the various design bureaus. Some papers seemed to be marketing efforts aimed at educating foreign attendees on the capabilities of the Russian technical agencies.

Papers of interest included flight safety in icing conditions presented by researchers from the Gromov Flying Research Institute (LII). It was a comparison of the damage tolerance of built-up and integrally stiffened structures from TsAGI, and a description of advanced aluminum alloy development from the all-Russian Institute for Materials (VIAM). The conclusions of the icing paper included recommendations for the removal of ice protection systems from the Tu-154M aircraft and to not install an ice protection system on the Tu-204. At the end of the presentation, a new speaker forcefully took the podium and emphatically stated the vast data on icing available in Russian sources and the desire to cooperate on icing work.

Tours were provided of a small portion of the vast TsAGI facilities including the Full-Scale Structures Durability Test Laboratory where full-scale service life (fatigue) testing of the Ilyushin-96 commercial transport, Tu-160 Blackjack strategic

bomber, and various helicopter components was in progress. The sight of simultaneous fatigue testing of two entire full-scale airframes was quite impressive. We visited the Subsonic Wind Tunnel T-101 (24m x 14m, elliptical section), built in 1939 and largest in the world until the construction of the NASA Ames 80' x 120' tunnel. The tunnel was being used to test a cable span bridge section. We also toured the Subsonic, Transonic, and Supersonic Wind Tunnel T-128 (2.75 x 2.75 m) a continuous operation, variable density tunnel with Mach range 0.15-1.7.

Concurrent with the symposium was the Moscow Air show (MAKS'99). Static displays included a myriad of Russian military aircraft including the Tu-144 Backfire and Tu-160 Blackjack supersonic intercontinental bombers. The latter had been retrofitted into a satellite launch role similar to the B-52/Pegasus function. Also on static display were recent Sukhoi fighters, MiG's from the -19 to the -31, and a number of cargo aircraft including the Ilyushin 96, Antonov 72, and an amphibious civilian firefighting aircraft from the Beria design bureau. Impressive military flying displays included the Sukhoi 35 (thrust vectoring), Sukhoi 37 (forward swept wing), and Antonov 72 (STOL cargo) aircraft.

For a listing of papers presented please contact Lt Col Rob Fredell. Conference proceedings (in English) will soon be available on CD-ROM.

Capt Tim Lawrence
Space Technology

Site Visit: **Surrey Space Centre, Guildford UK, 16 July 1999** The Surrey Space Centre presented the final results of a 3 month design study for a 100 kg microsat mission to geosynchronous transfer orbit. The mission objectives were to demonstrate proximity operations and a low cost hybrid upper stage propulsion system. Surrey discovered that geosynchronous transfer orbits create unique mission opportunities for conducting the proximity operations maneuvers due to the longer contact times with the ground station. The mission would allow 22 m/s for proximity operations and 200 m/s for hybrid upper stage firings. They also showed that a satellite could be built to meet these mission objectives for a cost of just over $5 million. For more information on this mission, please read: http://www.ee.surrey.ac.uk.

The University researchers also presented their preliminary work on nitrous oxide decomposition for microsatellite monopropellant applications. On 28 July, the University was the first-ever to fire a nitrous oxide resistojet in space on their UoSAT-12 spacecraft. AFRL/PR's Electric Propulsion Laboratory, USAFA, and EOARD sponsored this work. The performance results are as follows:

F = 93 mN
Isp = 95 sec
Burn time = 15 sec
DV = 18 mm/s
Tc = 180 C
Pc = 10 bar
Power = 91 W

The University plans on longer duration firings when the satellite is in a better solar cycle in mid September. Researchers are also conducting tests looking at catalysts so decomposition will occur at lower temperatures. Rhodium has given the best results, starting decomposition at 350 C, compared to thermal decomposition at 750 C. If you are interested in this work, please contact Capt Tim Lawrence.

CONFERENCE SUPPORT

EOARD promotes technical interchange by supporting and co-sponsoring technical workshops and mini-symposia at overseas conferences. We often receive in return proceedings and attendance for one or more Air Force representatives. Air Force R&D personnel attending or considering attending European conferences should contact EOARD for further information. For further details

on the conferences below contact the liaison officer indicated (see footnotes). **Bi-service and tri-service support efforts are in bold print.**

Dates (1999)	*Location*	*Conference/Workshop Title*	*LO[1]*
27 - 28 Aug 99	**U. of Natal, Durban, South Africa**	**1999 Quantitative Feedback Theory (QFT) Symposium http://www.ee.und.ac.za/symposium/default.htm**	**CNR**
29 Aug - 10 Sep 99	International Hotel, Millau, France	Microwave Superconductivity	BTM
4 - 10 Sep 99	Saint-Malo, France	The 1999 International Conference on Strongly Coupled Systems	BTM
5 - 10 Sep 99	**Florence - Italy**	**14th International Symposium on Air-Breathing Enfines (XIV ISABE) http://widget.ecn.purdue.edu/~isoabe/**	**CNR**
5 - 8 Sep 99	Bratislava, Slovakia	2nd Electronic Circuits and Systems Conference http://www.elf.stuba.sk/~ecs99	BTM
6 - 11 Sep 99	Dijon, France	Colloquium on High Resolution Molecular Spectroscopy	JJS
13 - 17 Sep 99	Tomsk, Russia	Atomic and Molecular Pulsed Lasers	CMS
13 - 15 Sep 99	Sevastopol, Crimea, Ukraine	International Conference on Antenna Theory and Techniques	BTM
14 - 17 Sep 99	Sitges - Barcelona, Spain	4th European Conference on Applied Superconductivity	BTM
20 - 23 Sep 99	**Seville, Spain**	**International Conference on Ceramics and Bi-metallic Interfaces**	**JJS**
20 - 21 Sep 99	Malvern, England	Workshop on Nonlinear Optical Materials	CMS
22 - 24 Sep 99	Bucharest, Romania	The 6th Symposium of Optoelectronics - SIOEL '99"	CMS
22 - 24 Sep 99	**St. Petersburg Russia**	**Applied Aspects of Interface Science (AAIS)**	**BTM**
27 Sep - 3 Oct 99	The Palace of Scientists, St Petersburg, Russia	The Future of Superconducting Rotating Machines	BTM
3 - 7 Oct 99	Kiev, Ukraine	International Conference "Advanced Materials" http://www.materials.kiev.ua/	RSF
11 - 12 Oct 99	Prague, Czech Republic	COIL R&D Worshop, Prague '99	CMS
1 - 5 Nov 99	Almaty, Kazakhstan	First International Kazakh-American Conference on Information and Control Systems	BTM
1 - 12 Nov 99	Isaac Newton Inst for Math. Sciences, Cambridge,UK	Models of Fracture	RSF
18 - 20 Nov 99	Bad Radkersburg	Assessment of stress intensity and stress compatibility in large groups under construction	BTM
27 - 29 Sep 00	Amsterdam	How eye movements serve the needs of vision in the natural world	BTM

[1] BTM-Barry T. McKinney; CMS-Martin Stickley; CNR-Charbel N. Raffoul; JAH-Jay A. Howland; JJS-Jerry J. Sellers; RSF- Robert S. Fredell;TL-Tim Lawrence

WINDOW ON SCIENCE

EOARD initiates and promotes technical liaison between Air Force and foreign scientists very effectively with the Window-on-Science (WOS) program, through which we can arrange and fund visits of foreign scientists to selected Air Force facilities. To nominate a WOS candidate contact your Technical Director or your EOARD discipline representative. WOS visitors currently on contract are listed below. For further details contact the liaison officer indicated (see footnotes). **Bi-service and tri-service coordinated visits are in bold print.**

Dates (1999)	*Traveler*	*Country*	*Topic*	*Location(s) of US Visit[1]*	*LO[2]*
1- 4 Sep 99	Dr. Daniella E Raveh	USA	Aerodynamics	Wright-Patterson, AFB, OH	JJS
1- 4 Sep 99	Professor Mordechay Karpel	USA	Aerodynamics	Wright-Patterson, AFB, OH	JJS
2- 3 Sep 99	Prof. Gyula Julius Vancso	Netherlands	Polymers and Scanning Force Microscopy	AFRL/ML. WPAFB, OH	CMS
3- 25 Sep 99	Dr. Yakov Benveniste	Israel	Heat conduction in composites	AFRL/MLBC. WPAFB, OH	CMS
4 - 14 Sep 99	Dr Hiltrud Lenke	Germany	Remediation of TNT-contaminated soil	Second International Symposium on Biodegradation of Nitroaromatic Compounds and Explosives, Xerox University, Virginia	MHS
4- 8 Sep 99	Dr. Alexander Fedorov	Russia	Boundary Layer	AFRL (WPAFB)	CNR
6-19 Sep 99	**Dr. Vassilios Theofilis**	**Germany**	**Modeling for Elliptic Cone and Open Cavity**	**AFRL(WPAFB)**	**CNR**
7-16 Sep 99	Prof. Fethi Sedat Tardu	France	Active & passive control of near wall turbulence	NASA Langley, AFRL (WPAFB); Turbulent Shear Flow Symposium (San Diego, CA).	CNR
7-11 Sep 99	Dr Hans-Joachim Knackmuss	Germany	Biodegradation of nitroaromatics	Second International Symposium on Biodegradation of Nitroaromatic Compounds and Explosives, Xerox University, Virginia	MHS

Dates (1999)	*Traveler*	*Country*	*Topic*	*Location(s) of US Visit*[1]	*LO*[2]
10- 18 Sep 99	Prof. Yakiv Shirman Prof. Yuriy Sedyshev	Ukraine	Antennas	HRS, TWENTY-THIRD ANNUAL Antenna Applications Symposium, Monticello Illinois	BTM
12- 18 Sep 99	Dr. Farrokh Vakili	France	Coronographic imaging by adaptive optics	Kirtland AFB, NM	CMS
14- 21 Sep 99	Prof. Dr. Klaus G Thoma	Germany	EMI	Lawrence Livermore Laboratory, Eglin AFB CA	TL
14- 30 Sep 99	Dipl.Ing. Werner Riedel	Germany	EMI	Lawrence Liuvermore National Laboratory, Air Force Research Laboratory Munitions Directorate	TL
15- 30 Sep 99	Prof. Volodymyr Malyutenko	Ukraine	IR LED's	AFRL/MN, Eglin AFB FL	GTO
18- 22 Sep 99	Prof. Bakhych Bairamov	Russia	Properties of ZnGeP2 and CdGeAs2	DERA, Great Malvern, UK	CMS
18 Sep - 2 Oct 99	Dr. Vladimir Fonov	Russia	Pressure Sensitive Paint Data Reduction Software	AFRL (WPAFB, OH)	CNR
18- 25 Sep 99	Dr. Nina Yurchenko	Ukraine	Flow Control	AFRl/WPAFB	CNR
18- 22 Sep 99	Prof. Lioudmila Issaenko	Russia	IR nonlinear optical materials	DERA, Great Malvern, UK	CMS
18- 22 Sep 99	Dr. Alexandre P. Elisseev	Russia	Spectroscopic properties of NLO materials	DERA, Great Malvern, UK	CMS
22 Sep - 9 Oct 99	Prof. Dr. Valentin. I. Vlad	Romania	Real-time holographic interferometry	AFRL/SNHX, Hanscom AFB, MA	CMS
26 Sep - 13 Oct 99	Prof. Ulf Von Zahn	Germany	lidar measurements in the middle atmosphere	HRS	KLM
29 Sep - 2 Oct 99	Dr Boris A Arkhipov Dr Vladimir Kim	Russia	Low power stationary plasma thrusters	Edwards AFB CA Electric Propulsion Laboratory	TL
1 Oct - 10 Nov 99	Dr Prof Marat S Soskin	Ukraine	Optical vortices	AFRL/DELO, Kirtland AFB, NM	CMS
3 Oct - 6 Nov 99	**Dr. Yury F. Kolesnichenko**	**Russia**	**Microwave and HF Discharges; Low-T Plasma Kinetics**	**Princeton U., AFRL/VA, JHU/APL**	**CNR**
5- 9 Oct 99	Dr Darren M Bagnall	United Kingdom	Zinc Oxide	AFRL/SN, Wright Research Site	JMS
5- 9 Oct 99	Dr Robert G. Triboulet	France	Growth of Zinc Oxide	AFRL/SN	JMS
6- 19 Oct 99	Dr. Vladimir Mocharov	Russia	Pressure Sensitive Paint	West Lafayette, AFRL (WPAFB), NASA Ames	CNR
9- 23 Oct 99	Dr. Kateryna Kalabukhova	Ukraine	Electron spin-resonance spectra in silicon carbide	SiC Meeting, Raleigh/Durham, NC; AFRL/MLPO, WPAFB, OH; and NRL/Code 6862, Washington, DC.	CMS
9- 16 Oct 99	Professor Brian D MacCraith	Ireland	Pressure Sensitive Paint	West Lafayette, AFRL (WPAFB)	CNR
14 Oct - 11 Nov 99	Prof. Chaiban Nasr	Lebanon	Neural Networks-Artificial Intelligence	U. of Missouri-ANNIE '99	CNR
15 - 23 Oct 99	Dr. Michel Salvator Israel	Bulgaria	human exposure to non-ionizing radiation	IEEE meeting, Atlanta; ARS	MHS
30 Oct - 6 Nov 99	Dr. Artur Krasilnikov Dr. Alexander Kuranov Dr. Vitalii V. Kislykh Dr. Anatoly F Kolesnikov Dr. Alexandre Kraiko **Dr. Evgueni Cheikine**	Russia	Hypersonic Systems	Norfolk, VA	CNR
30 Oct - 6 Nov 99	**Dr. Alexei Korabelnikov**	**Russia**	**Plasma Aerodynamics**	**Norfolk, VA**	**CNR**
30 Oct - 6 Nov 99	Dr. Valery V. Lazarev Dr. Alexandre Lanshin Dr. Vitali Smoliarov Dr. Nicolay Anfimov Dr. Kirill Khodataev Dr. Vladimir Levine Dr. Igor Timofeev Dr. Gorimir Chernyi Dr. Serguei Kostromin Dr. Vladimir Sosunov	Russia	Hypersonic Systems	Norfolk, VA	CNR
30 Oct - 6 Nov 99	Dr. Nikolai Dembo	Russia	Hypersonic Systems; Aeroengines	Norfolk, VA	CNR

[1] AFRL Research Sites–**ARS**: Armstrong Research Site, Brooks AFB, TX; **ERS**, Edwards Research Site, Edwards AFB, CA **HRS**: Hanscom Research Site, Hanscom AFB, MA; **PRS**: Philips Research Site, Kirtland AFB, NM; **RRS**, Rome Research Site, Rome, NY; **WRS**: Wright Research Site, Wright-Patterson AFB, OH; Other sites: **AEDC**: Arnold Engineering Development Center, Arnold AFB, TN; **USAFA**: Air Force Academy, Colorado Springs, CO; **ARL**: Army Research Laboratory

[2] BTM-Barry T. McKinney; CMS-Martin Stickley; CNR-Charbel N. Raffoul; GTO-Gerald T. O'Connor; JJS-Jerry J. Sellers; RSF-Robert S. Fredell; TL-Tim Lawrence

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